Appendix F

Testimony to the Committee on
Energy & Natural Resources,
United States Senate
(Global Warming and Ocean Conditions)

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TESTIMONY TO THE COMMITTEE ON ENERGY & NATURAL RESOURCES, UNITED STATES SENATE

Written Submission by

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Introduction

Chairman Smith, honourable members of the Committee, it is an honour to be invited to present testimony before you.

I have been studying the biology of Pacific salmon in the ocean since 1990, when I started the High Seas Salmon research program for the Canadian Government. Most of my research has occurred in that vast arc that stretches from southern British Columbia to the Aleutian archipelago of Alaska, and offshore. Our studies demonstrate that this region forms a narrow coastal corridor through which most of the young salmon from the west coast of both Canada and the United States migrate.

As a result of this research, we have found a number of disturbing changes taking place in the ecosystem of the Northeast Pacific Ocean. I believe that several of these new findings highlight to a much greater degree than previously believed the importance of the ocean to determining the productivity and sustainability of salmon on the West Coast of North America. These results are of equal interest to the people of Canada and the United States. My research, and that of my Canadian colleagues, shows that large numbers of Washington and Oregon salmon, including threatened stocks such as the Snake River chinook, also move into the waters of coastal British Columbia.

I must preface my comments by emphasising that salmon are unique animals, and spend time in both freshwater and ocean environments in order to complete their life cycle. Because this cycle must be completed to perpetuate the species, disruption at any point in the life cycle can reduce the productivity of salmon stocks. I would like to stress at the outset that although our research is pointing towards a greater overall influence of the ocean on salmon survival than freshwater, nothing in what we have found should be taken to mean that the freshwater habitat is unimportant. Rather, in this period of massive reductions in ocean survival, the importance of preserving and rehabilitating damage to the freshwater habitat is even more essential. However, I also believe that failure to understand and address the enormous changes confronting us in the ocean will cost us far more in terms of remedial and sometimes misdirected efforts than would a direct effort to evaluate the causes of these changes.

Changes in Ocean Survival

There has been a widespread assumption that because the ocean is large it is a more stable habitat for salmon than the freshwater environment. Thus when salmon production drops, it has generally been assumed to be because of degradation of the freshwater habitat. Most regulations aimed at protecting or improving freshwater habitat have made the assumption that when something bad happens to salmon production it has a freshwater cause. Almost all biological research on salmon has also focussed on the freshwater phase of the life cycle.

We now know that the assumption that the ocean is a relatively benign and unchanging habitat for salmon is untrue. Enormous reductions in ocean survival of many species of Pacific salmon have occurred. In Oregon, marine survival of coho salmon (exclusive of fishing effects) has dropped to only 1/10th of the level experienced only 2 decades ago. Beginning around the start of this decade, the ocean survival of many stocks of British Columbia salmon also began to fall, sharply reducing overall abundance and pushing several stocks of coho close to extinction. Most recently, changes in the ocean survival of Alaskan salmon have sharply reduced catch levels, causing severe economic dislocation in Alaska as well.

In each region, the primary cause of the sharp declines has been a change in ocean survival. A key issue hampering informed debate of what has been developing has been a lack of several types of monitoring. Monitoring is necessary in order to allow clear separation of freshwater from marine survival events on salmon productivity. Monitoring and focussed ocean research are also necessary to allow us to understand what the processes are that are causing these enormous reductions in the quality of the ocean habitat for salmon. For example, we know that plankton quadrupled in abundance between the 1960s and 1980s in the northern Gulf of Alaska, a time of rapid increase in Alaskan and British Columbia salmon populations. However, we do not know now whether or not the plankton has changed again in the 1990s, although the climate certainly has.

There is a lack of understanding of how much and how quickly the oceans have already changed and, as yet, little scientific basis to determine how much more the ocean conditions affecting salmon survival may deteriorate. In my view, it is critical to establish the relative impact of freshwater and ocean changes on determining the health of salmon populations and an improved understanding of the underlying causes of poorer ocean survival as quickly as possible. Our lack of understanding is hampering the development of a broader perspective and an informed debate over how best to manage salmon populations, and what the importance of ocean changes to current salmon problems is.

If I were to tell you that only 1 stream in 10 was still producing salmon after two decades, I am certain that there would be an immediate demand to determine why such enormous changes could happen so rapidly, and what the consequences would be for our ability to manage these resources. Yet these changes have happened in the ocean, but it has only been with considerable difficulty that we have been able to address what has happened. Part of the difficulty has been a general scepticism that we can successfully work in the ocean—it has been assumed that it is too large to permit research efforts from being successful, and that somehow, the size of the ocean confers stability. Neither is true.

To put these changes in perspective, the changes in ocean habitat are now only returning 1 adult for every 10 that would have returned in earlier, more productive, times. Yet large-scale commercial fisheries typically harvest about 70% of the returning adults, taking 2 out of 3 returning adults. The rapid changes in ocean climate are clearly capable of wiping out the ability to have a commercial fishery in the space of only a few years, making formerly productive self-sustaining populations no longer viable even in the absence of exploitation. These are massive changes.

Changes in Nutrients

The work of my colleagues and myself at sea indicates that there are massive changes occurring in the north-eastern Pacific. Perhaps most important, there are dramatic changes in the ocean ecosystem as a result of nutrient depletion in the 1990s. This is apparently the result of a "sealing off" of the nutrient-rich deep ocean from the surface layer where most biological activity occurs.

In simplest terms, the ocean is composed of two layers. The deep layer is rich in nutrients, but has no light. Plants cannot grow. Above the deep ocean lies the sunlit surface layer. Here plants grow until they use up the nutrient. The surface layer is warmer and less salty (because of freshwater coming from rainfall, river run-off, and snow melt). It floats over the deep ocean. In the 1990s we have seen an unprecedented shutdown in the food chain supporting fish, because changes in the climate seem to be sealing off the surface layer from the deep ocean nutrient reservoir.

Plants need light and nutrients to fuel the bottom of the food chain, whether on land or in the ocean. In the early 1990s nitrate (an essential plant nutrient) began to be completely used up by the end of summer in the surface layer, something never before observed in the Eastern Pacific. My Canadian colleague Frank Whitney who identified this change estimated in a recent paper that new biological production was reduced by 40% in 1994 relative to what was possible in the 1980s.

More recent declines in nutrient availability are even more worrisome. Nitrate disappeared from the surface waters off Vancouver Island in early spring of 1998, and did not reappear for the remainder of the summer growing season. The research surveys I collected nutrient data on also found no measurable nitrate in mid-summer for most of the surface waters stretching from northern Vancouver Island all the way along the coast of North America to the Aleutian Islands in 1997 and 1998. Nitrate was absent in a band stretching out to sea for at least 100 miles from shore. This is precisely the habitat used by young salmon in the first stage of their ocean migration.

Unfortunately, there was essentially no ocean monitoring in Alaska or northern British Columbia waters prior to our surveys. As a result, the only area where we are completely certain that the disappearance of this essential nutrient is a new phenomenon is the ocean waters off southern British Columbia, because of a long-standing monitoring effort by the Canadian government in this region. Without sustained monitoring over a number of years it is impossible to be certain how widespread the surprising findings off Vancouver Island extend, and the extent that they are caused by the rapidly changing climatic conditions being experienced in the 1990s.

Migration of Young Salmon

After entry into the ocean, our surveys show that most young Pacific salmon move rapidly north along the coast and out beyond the Aleutians—much farther than had previously been thought. However, we also know that significant numbers of coho and chinook remain in southern regions, and feed year-round in the coastal waters off the west coast of Vancouver Island.

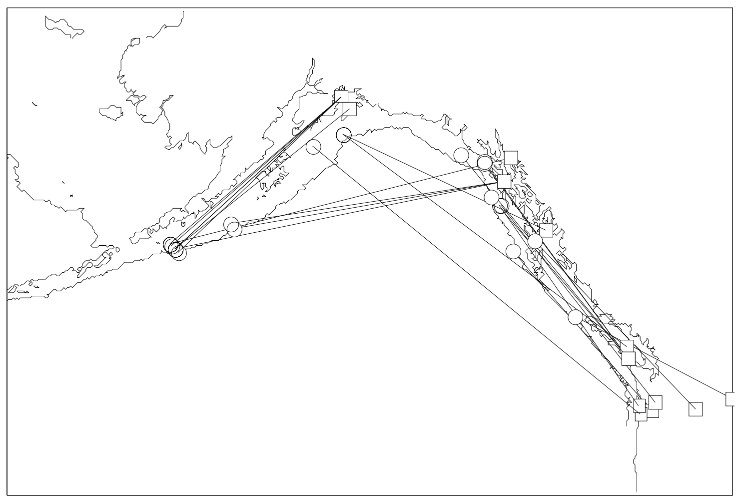

Fig. 1. Long-distance recoveries of PIT-tagged or CWT tagged chinook and coho salmon (circles). The southernmost release points (squares) are of Columbia River fish recovered in British Columbia or Alaskan coastal waters. All of these juvenile salmon were recovered in their first summer or fall of ocean life far from the Columbia River.

We also found from our ocean surveys in 1998 that during the first week of June, CWT and PIT tagged chinook and coho salmon from the Columbia River were caught off northern Vancouver Island (*see Figure 1*). Based on their release times in freshwater, these salmon moved rapidly along the continental shelf from Oregon up into central British Columbia waters. Continuous movements of greater than 200% of "normal" swimming speeds were necessary to have covered the distance from release to the B.C. recovery sites. Thus a very substantial component of Columbia River chinook and coho stocks move rapidly out of the Columbia River plume into Canadian waters, and are therefore exposed to the poor ocean conditions we have found farther north.

My 1998 surveys demonstrated that by the end of August, no juvenile salmon remained in waters off central and northern British Columbia, confirming evidence from my three years of earlier work of the rapid migration north and along the shelf. Based on our collected evidence we know that these animals continued to move north and west to the

Aleutian Islands by the beginning of December without leaving the continental shelf. However, we also demonstrated from the 1998 work that there were substantial stocks of coho and chinook salmon still present in southern British Columbia coastal waters much later in the autumn. Based on CWT returns from winter fisheries formerly operating in the area, these salmon are known to be from southern British Columbia and Oregon-Washington stocks that overwinter off Vancouver Island, and include such endangered stocks as the Snake River chinook.

Causes for Reduced Ocean Survival

Our 1998 surveys indicate that the growth and general condition of the chinook and coho salmon stocks found in the coastal waters of southern British Columbia is greatly reduced compared to that of the salmon feeding farther to the north. They are stunted in size and also have lower fat reserves to carry them through the winter months. Our preliminary analysis is that there may be up to a 7-fold difference in survival between those stocks that stay to feed in southern regions of British Columbia waters relative to those that migrate further north. Thus these differences in growth, which are probably related to the disappearance of a critical nutrient from the surface waters, appear to be capable of explaining most of the reduced ocean survival of Columbia River and southern British Columbia chinook and coho salmon stocks.

Global Warming and Climate Change

Our open ocean salmon research, conducted from 1990-95, also indicates that salmon are headed for trouble in the long term because of global warming. We have found that all species of Pacific salmon have extremely sharp limits to where they will go in the ocean.

These limits are determined by ocean temperature. Increases in sea temperature increase metabolic rates in salmon. This causes them to use more energy. We suspect that the temperature limits that we have found occur because they mark the boundary in the sea where energy demands exceed the energy gained from feeding, so that they cannot grow. Again, as with our coastal work on the survival of young salmon, growth is implicated in important aspects of their offshore biology as well.

The amount of warming projected to occur over the next 50 years because of increased greenhouse gases is sobering. The projected warming is sufficient to move the temperature limits determining where salmon may successfully grow entirely out of the Pacific Ocean and well up into the Bering Sea (*Figure 2*). Thus there is reason to believe that several species of Pacific salmon may no longer forage successfully in the Pacific Ocean within our lifetimes if greenhouse gases continue to increase at their present rate.

Because salmon home to the river of their birth with great fidelity, it is unlikely that salmon from the Pacific Northwest will suddenly move elsewhere to reproduce. The great preponderance of scientific evidence indicates that the world will warm by about 5°F over the next 60 years because of global warming. Although there are questions about the timing and rapidity of the increase in warming, it is virtually certain that salmon will find themselves migrating back through larger areas of the Gulf of Alaska that will no longer support growth. As a result, it is likely that they will return to their streams much smaller, with fewer eggs, and lower energy reserves to fuel the upriver migration. This will further complicate attempts to compensate for the reduced ocean survival that we are seeing.

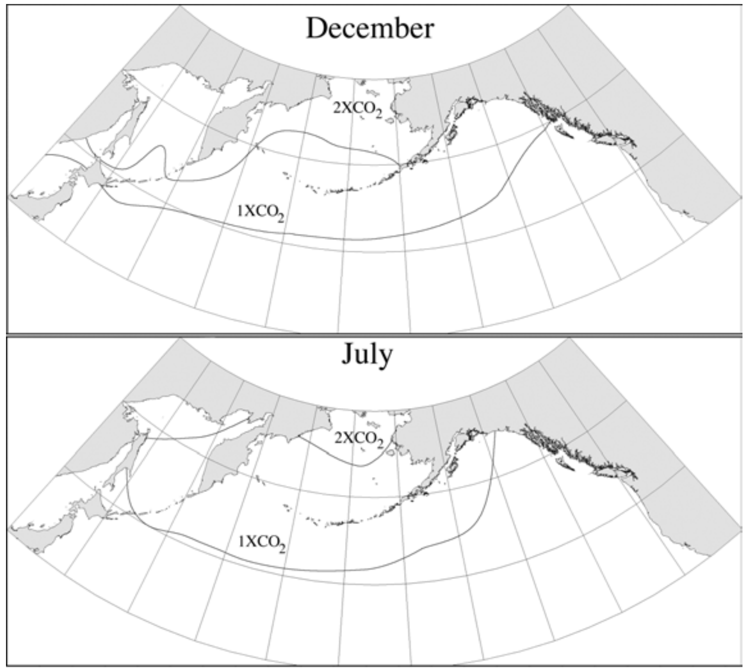

Fig. 2. The likely future distribution of sockeye salmon if global warming projections prove accurate. The current winter and summer distribution ($1xCO_2$) is compared with the projected position in 60 years (when CO_2 levels are projected to double). Results are similar for other species of salmon. We believe that the area vacated will not be able to support salmon growth.

The effects of the 1997 El Nino, which warmed the Pacific by about 5°F, are a case in point. Sockeye returning to the Fraser River in southern British Columbia were amongst the smallest on record, and had 20% lower energy reserves. Mortality of adult salmon within the river, also warmed by the El Nino, reached 76% for one stock, and neared 50% for other important runs. Thus I can tell you with some confidence that warming of the climate does not bode well for many of the salmon resources of Canada or the United States.

These are important public policy questions that need to be addressed. Ironically, it is unclear to me at this point whether or not the survival of salmon might be more impacted over the long term by the disruptions caused by dams in-river or by the added warming that would result from replacing this needed hydropower with coal-fired generating plants. However, it is clear that if events occurring in the ocean go unheeded and unstudied, then all of the blame will be mistakenly placed on failure of our efforts to redress freshwater habitat problems.

Conclusions

Mr Chairman, as I indicated at the outset, the enormous changes in ocean survival do not mean that efforts to protect and rehabilitate freshwater habitat for salmon should either be abandoned or lessened. However, it is my professional opinion that the declines in marine survival observed over the last two decades have been at least as large as the changes in freshwater survival. They may even be larger. Failure to recognize that these changes in the ocean are occurring and to establish why may compromise our ability to assess rehabilitation efforts and protect freshwater habitat for salmon.

For these reasons I stress that the salmon life cycle needs to be maintained everywhere. This means preserving freshwater habitat as well as recognising the importance of the oceans to the health of salmon stocks. However, the changes in marine survival are very alarming. They have occurred extremely rapidly, and swiftly made formerly healthy populations unsustainable even with the termination of all fisheries. These are sobering changes. As I have indicated in my testimony, they indicate the importance of the oceans to determining the overall health of these populations, and the ability of changes in ocean climate to compromise otherwise well-intentioned efforts at restoration.

The work in Canada is showing that the changes in climate are sealing off the surface layer from the nutrients in the deep ocean. My colleagues and I believe that underlying the climatic changes affecting salmon in the 1990s is the warming and freshening of the surface layer, which is cutting off the nutrients needed by the plants to fuel the food chain. It is early days yet, but we are finding that nutrient depletion and declining salmon survival seem to be related to increases in freshwater input and higher sea temperatures.

Although we do not possess the ability to deliberately "fix" the changes in the ocean that we are documenting, the success of our research program demonstrates that it is possible to quickly learn a great deal about what is occurring within the ocean to salmon. Salmon do not heed political boundaries. I would urge you to support the monitoring and scientific research needed on both sides of our border to understand what is happening now in the ocean. We need to develop this information now to better inform the public policy debate concerning these important west coast resources, and to correctly identify and evaluate where the troubling problems that we are grappling with have their source.

Finally, I believe that we need this information because the enormous changes in our Pacific salmon stocks in the 1990s are, in my view, a harbinger of what is likely to come. The best scientific evidence is that global warming will begin to change the climate of the Pacific Northwest. It is my personal opinion that the effects of global warming are behind the massive shifts in the ocean ecosystem structure that we are already seeing in the 1990s, and which seem to be causing such profound disruptions to the marine phase of the salmon's life cycle. Even if the recent changes are due to other climatic fluctuations, they are having very similar effects to what mild global warming is likely to do.

These climatic effects are probably going to compound in future. Without sound scientific understanding of what is now happening in the oceans to complement the excellent scientific work in freshwater, public policy decisions on both sides of the border may be compromised. Costly mistakes are likely. I can advise you that in my view it is critical that we develop a better ability to monitor the oceans, and document and evaluate the changes now underway for salmon. It is equally important that support be marshalled for focussed ocean research surveys to rigorously establish the reasons the salmon are dying. Ignorance, whether deliberate or unintentional, is a costly alternative.

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